Photon statistics of high-β quantum dot photonic-crystal lasers

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We demonstrate the photon statistics of InAs quantum-dot (QD) photonic-crystal (PC) lasers with high spontaneous emission coupling factors, $\beta > 0.25$. Such high β factors lead to the onset of lasing at incident pump powers < 40 W/cm^2 and pronounced linewidth narrowing above threshold. Measurements of the second-order correlation function, $g^{(2)}(T)$, confirm that a transition of the photon statistics from random spontaneous emission to coherent stimulated emission occurs. We then use the Fano-Mandel parameter[1], $F = [\langle a^+aa^+a\rangle - \langle a^+a\rangle^2] / \langle a^+a\rangle$, to demonstrate the first direct identification of lasing threshold in high-β, soft-turn-on devices.

With further optimization of QD placement using active positioning schemes[2], we expect to realize a thresholdless laser operating on a single QD.

[1] R. Loudon, *The Quantum Theory of Light* (Oxford University, New York, 2000)
[2] A. Badolato, K. Hennessy, M. Atature et. al. in publication, Science (2005).